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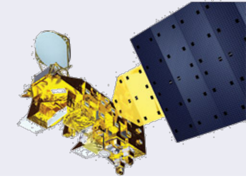


Increase in the frequency Severe Storms

Hartmut H. Aumann and more
Jet Propulsion Laboratory
California Institute of Technology

25 November 28, 2019

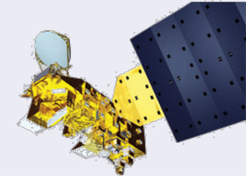
AIRS

AIRS Trends in 17 year

SST and Severe storms in the tropical Oceans

What does this mean for severe storms on land and hurricanes

AIRS Designed for Accuracy and Stability. Launched 2002. Predicted EOL 2024+



AIRS Features

Orbit: 705 km, 1:30pm, Sun Synch

Pupil Imaging IFOV : 1.1° x 0.6°
(13.5 km x 7.4 km)

Scanner Rotates about Optical Axis

Full Aperture OBC Blackbody, ε>0.998

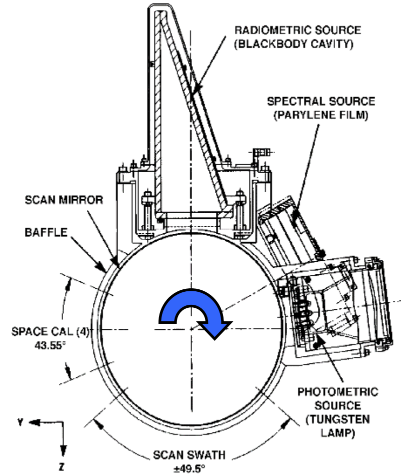
Full Aperture Space View

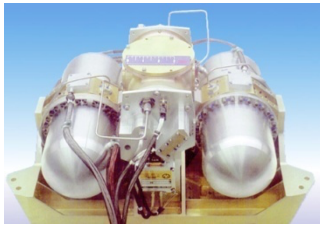
Solid State Grating Array Spectrometer

Temperature Controlled
Spectrometer: 158K

Actively Cooled FPAs: 60K

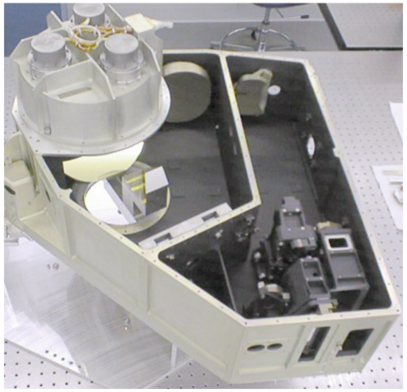
Mass: 177Kg,
Power: 256 Watts,
Life: 5 years (7 years goal)





Active Detector Cooling

Instrument Temperature Controlled at 158K



Grating Spectrometer

IR Spectral Range:
3.74-4.61 μm, 6.2-8.22 μm, 8.8-15.4 μm
IR Spectral Resolution:
≈ 1200 ($\lambda/\Delta\lambda$)
No. IR Channels: 2378 IR

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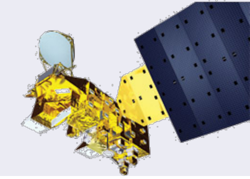
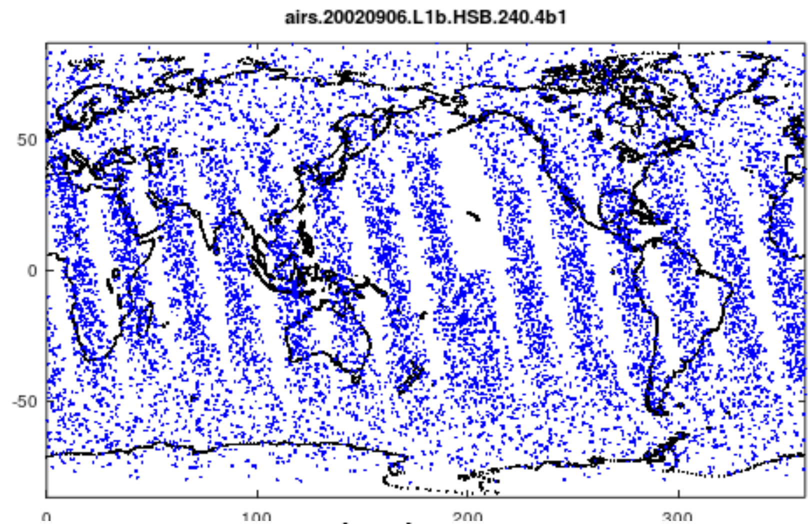
AIRS data are amazingly accurate and stable



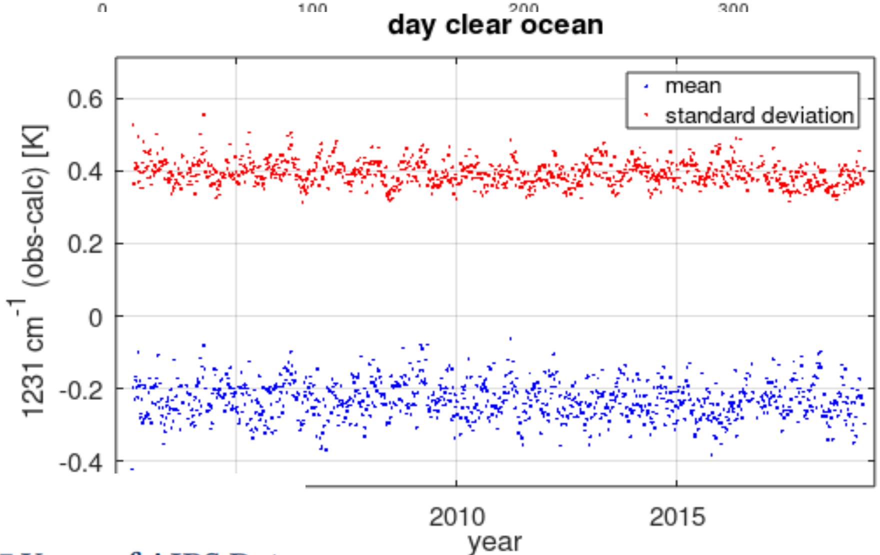
One 2378 channel spectrum every 22 msec
= 3 million spectra per day
It takes 20 minutes to read one day of AIRS data
We now have 17 years of data.
We have created a data subset: ACDS

The ACDS includes 150,000 spectra each day
20,000 area representative random global samples from the1:30 PM overpasses shown on the right.



Example from 2002/09/06:
13,000 points are clear day 30S-30N ocean
Position match the points with ground truth (CMCSST) Calculate the surface temperature from AIRS (sst1231)mean(sst1231-CMCSST)=-0.25K, standard deviation=0.36K.

Do this for all 17 years. Result for every 6th day is shown on the right. Mean bias -0.23K, bias trend -0.8+/-0.4 mK/yr. Mean standard deviation 0.39K, trend -1.4+/-0.2 mK/yr



Geophysical Research Letters

RESEARCH LETTER
10.1029/2019GL085098

Key Points:
- For climate research trend artifacts in the measurements have to be less than 10 mK/yr.

Radiometric Stability Validation of 17 Years of AIRS Data Using Sea Surface Temperatures

H.H. Aumann[1], Steve Broberg[1], Evan Manning[1], and Tom Pagano[1]

[1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA

Trends in 17 years of data have little climate significance

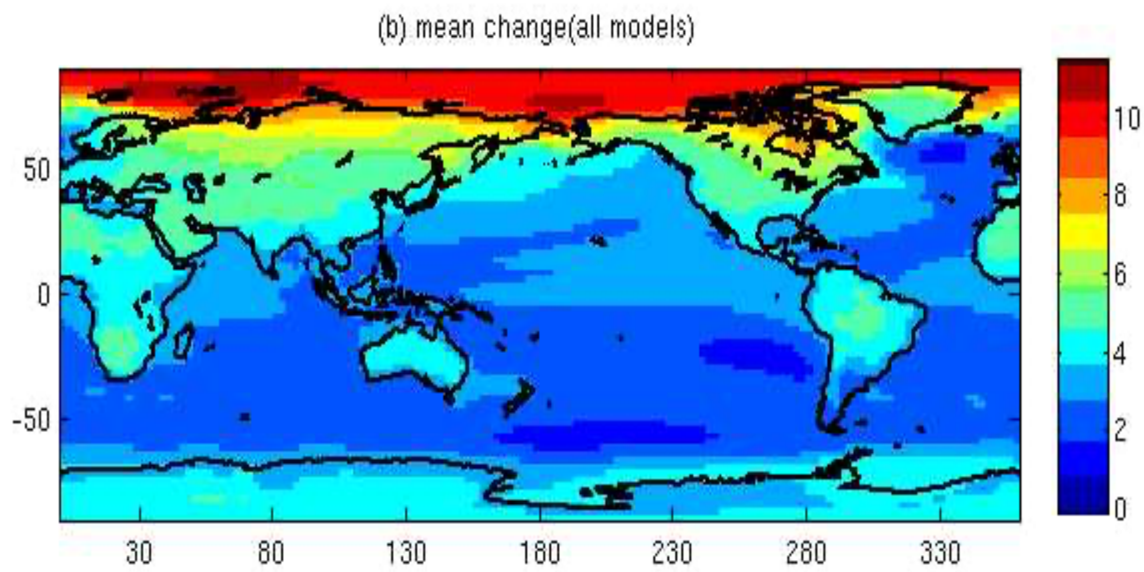
The correlation between processes can
have climate significance.

Process correlation (illustrated with Deep Convective Storms)

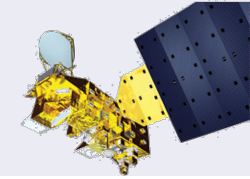
The surface temperatures are predicted to increase on average by 3K for the tropical ocean in the next 100 years.
Temperature time derivative = dSST/dt

The sensitivity of a process to surface temperature may be derived, dP/dSST,

dP/dt = dP/dSST * dSST/dt gives an estimate of change in the process with temperature.



Deep Convective Clouds and their correlated with the SST



What are DCC and what do the IR spectra look like: Aumann and Machado, ACP 2011

Increase in the frequency severe storms in a warmer ocean based on the correlation between SST and DCC frequency: Aumann, Ruzmaikin and Teixeira, GRL 2013

Increase in the frequency severe storms in a warmer ocean based on the DCC onset threshold in a warming ocean. Aumann, Behrangi, Wang GRL 2018

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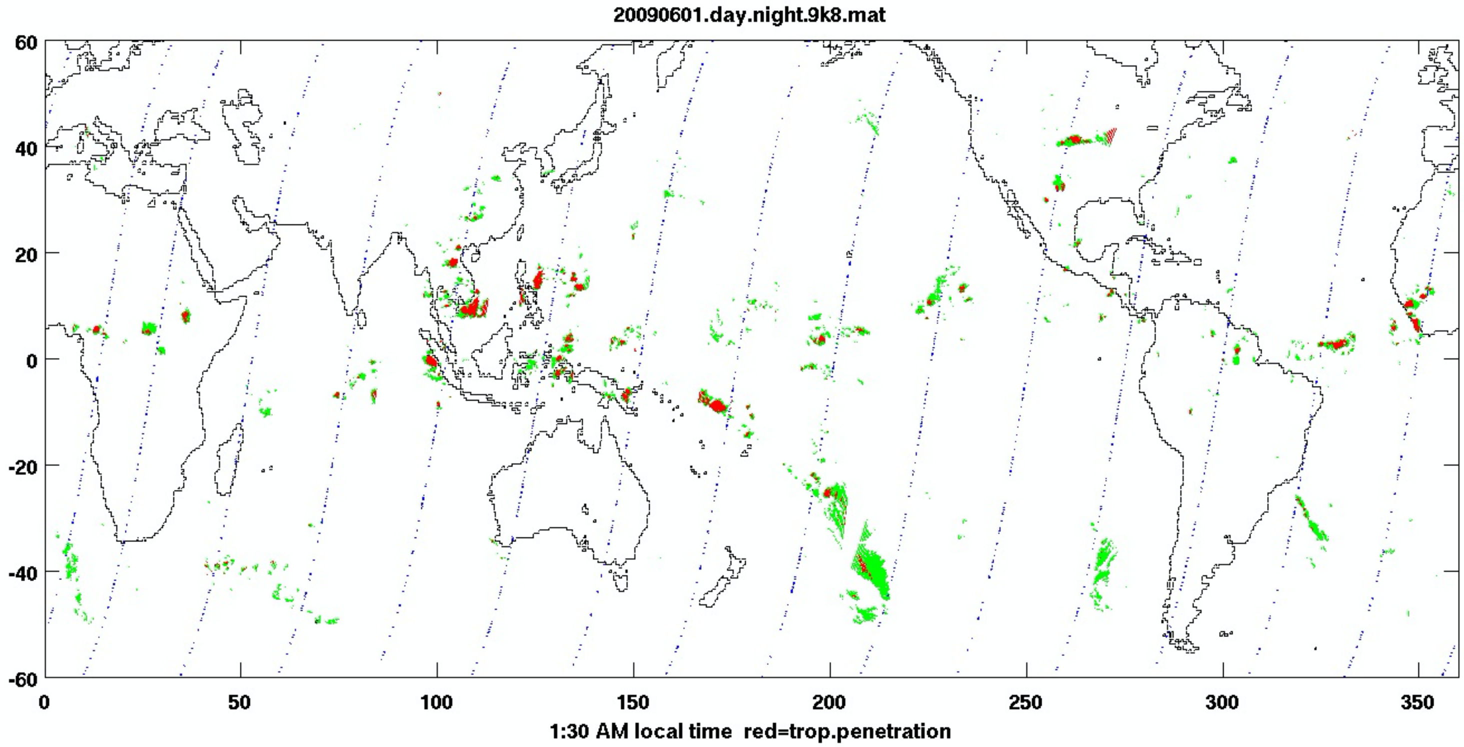
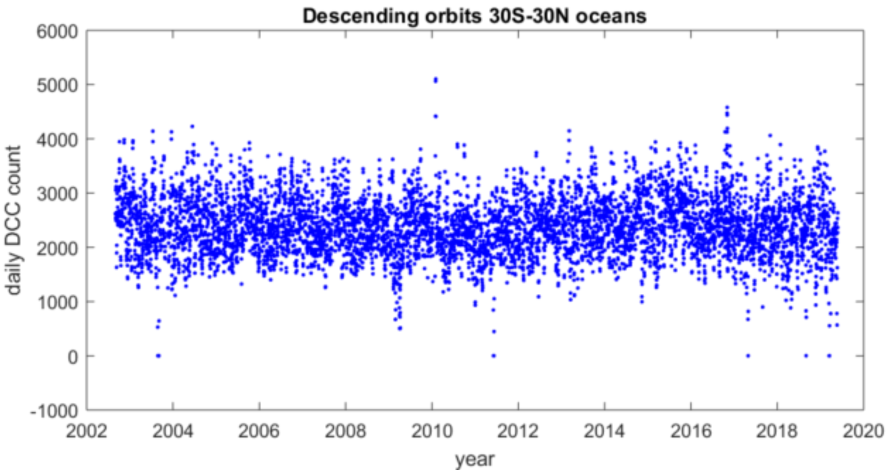
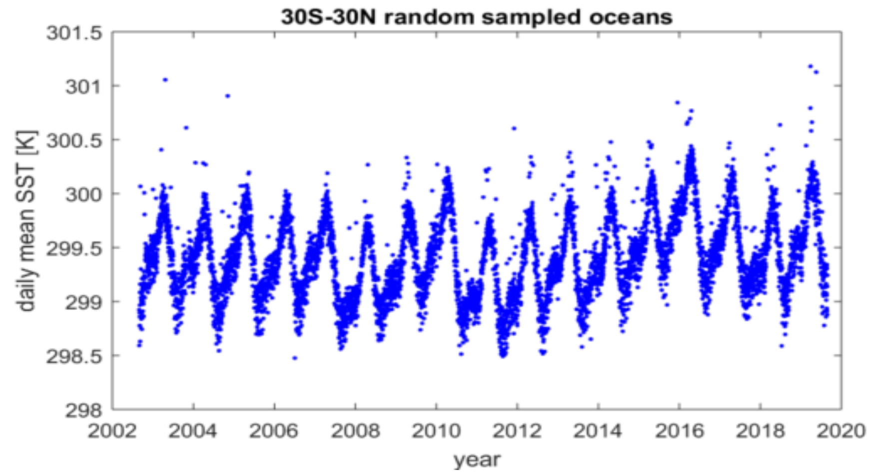
Deep Convective Storms (DCC) are large and powerful thunderstorms Typically the for cluster of 2 or more larger than 40 km.

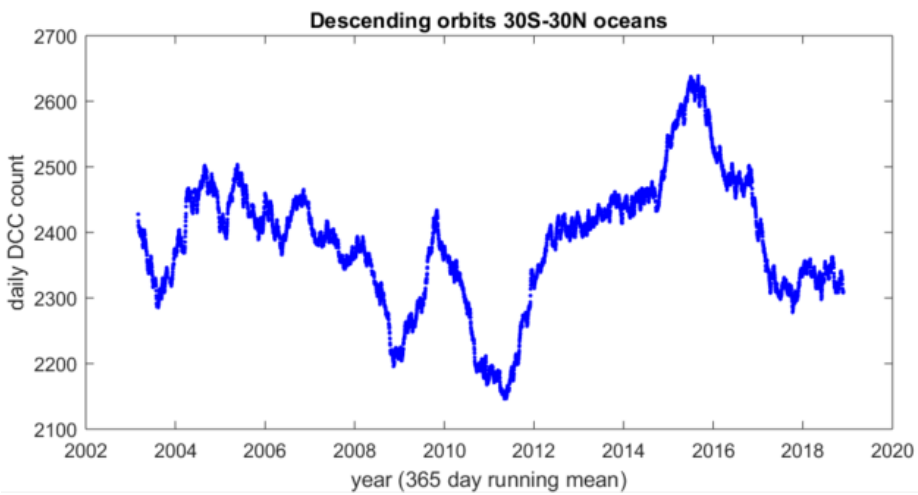


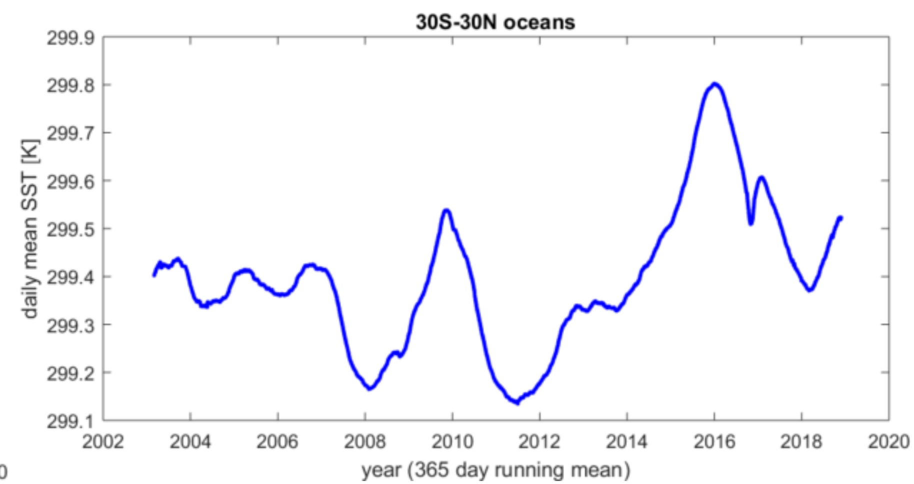
DCC are detected in the IR as cloud tops colder than 210K
Used by NFS for severe weather forecast, aviation alerts and proxy for rain rate.

The correlation between the DCC frequency and the mean SST emerges when using annual means (365 day running mean)









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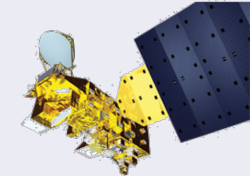
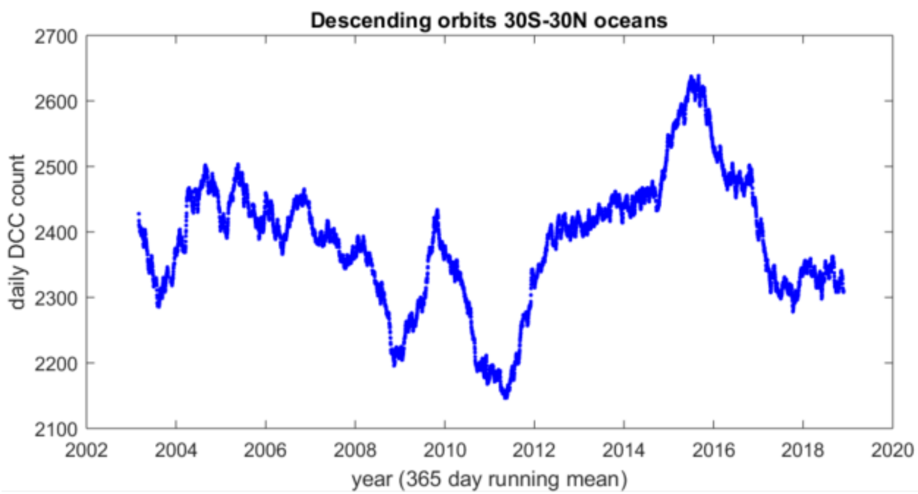
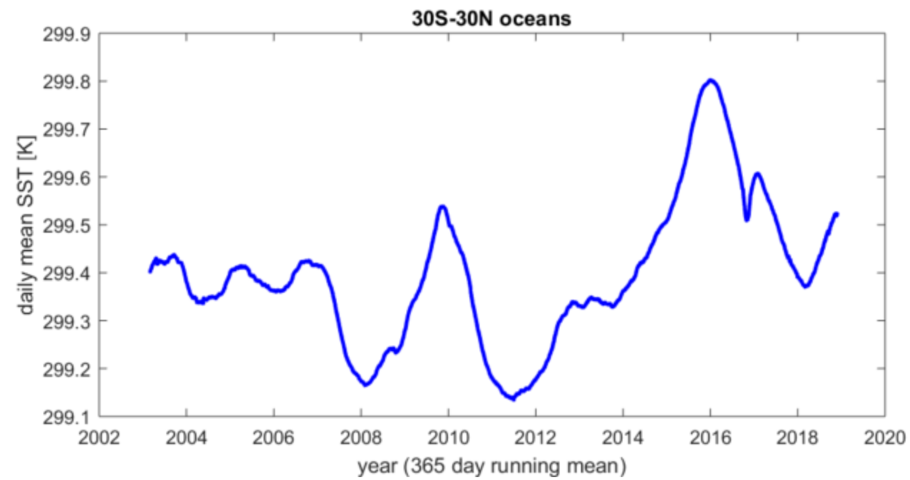
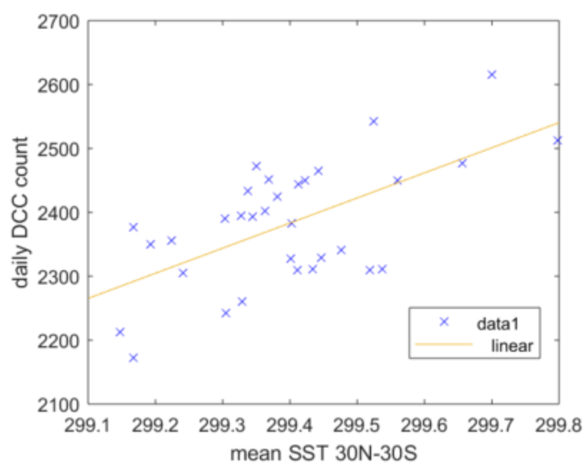


The frequency of DCC is correlated with the SST





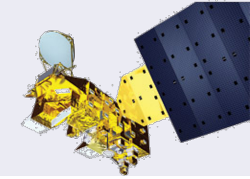
Resample the 365 day running mean every 182 days and plot the daily DCC count as function of the daily mean SST



The slope is +16+/-8 %/K
The frequency if DCC increases 16%/K increase in the SST

This is basically the approach taken by Aumann, Ruzmaikin and Teixeira, GRL 2013 with 10 years of data

The 2018 paper explains the increase in terms of an onset threshold



AGU100 ADVANCING EARTH AND SPACE SCIENCE

Geophysical Research Letters

RESEARCH LETTER
10.1029/2018GL079423

Increased Frequency of Extreme Tropical Deep Convection: AIRS Observations and Climate Model Predictions

Hartmut H. Aumann[1], Ali Behrangi[1,2], and Yuan Wang[1,3]

[1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA, [2]Department of Hydrology and Atmospheric Sciences, University of Arizona, Tucson, AZ, USA, [3]Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA, USA

Key Points:

- Based on AIRS observations the frequency of extreme (tropopause overshooting) deep convective clouds (DCCs) is expected to increase about 21%/K of warming of the tropical oceans

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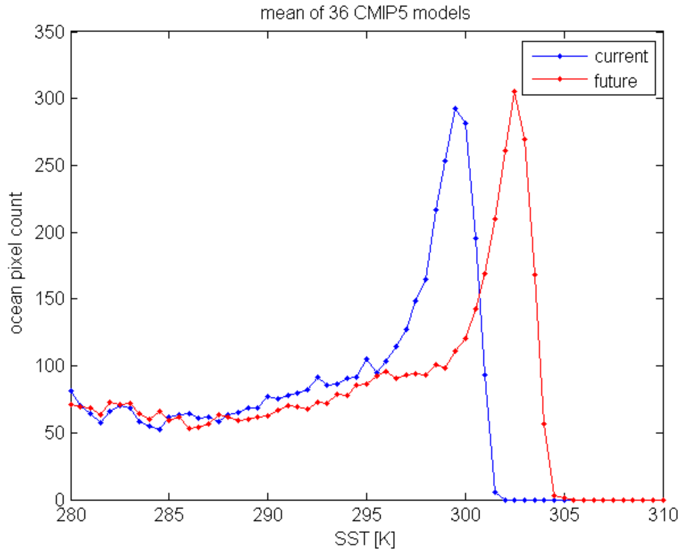
NEWS | JANUARY 28, 2019

Warming Seas May Increase Frequency of Extreme Storms

The mean temperature of the tropical oceans in the CIMP5 models, in the 1%/year CO2 increase since 1850 scenario, increases 3K from the present by the end of this century.



The histogram of the current temperature in the tropical oceans (blue) is surprisingly similar to the histogram predicted by CMIP5 for 2100 CMIP5 (red).

The GRL paper analyzes convective adjustment of the onset temperature of DCC

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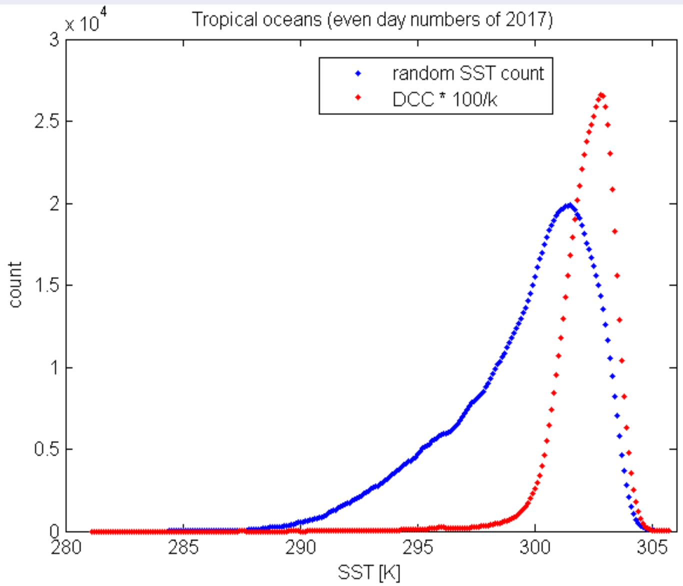

As the ocean warms, the DCC onset threshold shifts to warmer temperatures due to a convective adjustment.

For not overshooting DCC the threshold shift 1K per K of ocean warming. No change in the frequency of these DCC

For tropopause overshooting DCC the convective adjustment is not fast enough. For the most extreme DCC (190K) the adjustment is only 0.3K/K. Their count increases in a warmer ocean.

For the most extreme DCC the increase is 21%/K.
For clouds at or below the tropopause there is no change in the frequency

Relevance to Land storms and Hurricanes

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At 5PM in Kansas on August 21, 2009
AIRS overpass at 1:30 PM and 1:30 AM
Nothing was detected. Wrong time or too small.

Relevance to severe Land storms

The DCC are detected by AIRS

The warmer the land, the more severe storms

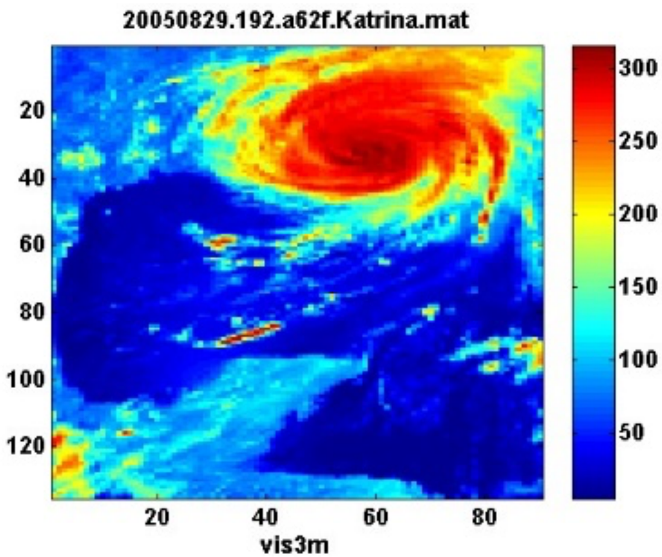
The mechanism is different.

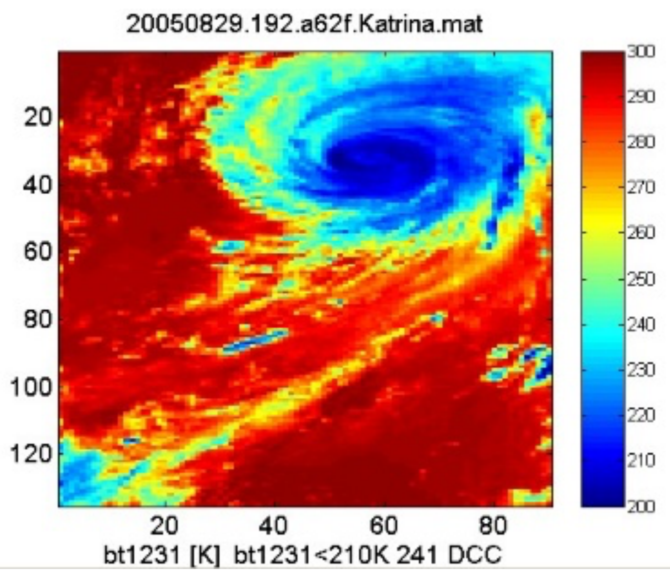
Land is not effective in storing energy.

The energy comes from the collision of frontal zones

For ocean the 50 meter thick mixed layer stores energy.

Relevance to Hurricanes





Hurricanes and typhoons appear to AIRS as clusters of DCC

The DCC don’t move, but the reform as the thermal instability r moves.

Conceptually, the more DCC, the larger the hurricanes

There are not enough hurricanes in the airs data record to establish a secure correlation.

Summary

The frequency of severe storms over ocean increase 21%/K increase in the global mean SST.

While the increase in the frequency of severe storms over land and the increase in the frequency of hurricanes over ocean in a warmer climate are intuitively reasonable, we have not been able to quantify this effect with AIRS data.